55 6942

Final Report for NASA Grant NAG 3-2102

Numerical Simulation of Screech Tones from Supersonic Jets : Physics and Prediction

submitted by

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Summary of Research
Grant NAG 3-2101

The objectives of this project are :

1. To perform numerical simulation of the jet screech phenomenon

2. To use the data of the simulations to obtain a better understanding of the physics of jet screech.

The original grant period was for three years. This was extended at no cost for an extra year to allow the principal investigator time to publish the results.

We would like to report that our research work and results (supported by this grant) have fulfilled both objectives of the grant. The following is a summary of the important accomplishments.

a. We have now demonstrated that it is possible to perform accurate numerical simulation of the jet screech phenomenon. Both the axisymmetric case and the fully 3-dimensional case were carried out successfully. It is worthwhile to note that this is the first time, the screech tone phenomenon has been successfully simulated numerically.

b. All four screech modes were reproduced in the simulation. The computed screech frequencies and intensities were in good agreement with the NASA Langley Research Center data.

c. The staging phenomenon was reproduced in the simulation.

d. The effects of nozzle lip thickness and jet temperature were studied. Simulated tone frequencies at various nozzle lip thickness and jet temperature were found to agree well with experiments.

e. The simulated data were used to explain, for the first time, why there are two axisymmetric screech modes and two helical/flapping screech modes.

f. The simulated data were used to show that when two tones are observed, they co-exist rather than switching from one mode to the other, back and forth, as some previous investigators have suggested.

g. Some resources of the grant were used to support the development of new

computational aeroacoustics (CAA) methodology. (Our screech tone simulations have benefitted because of the availability of these improved methods).

Publications supported by the grant.

1. Tam, C.K.W. and Auriault, L. *Jet mixing noise from fine scale turbulence* , AIAA Journal, 37, 145–153, 1999.

2. Tam, C.K.W. and Kurbatskii, K.A. *A wavenumber based extrapolation and interpolation method for use in conjunction with high-order finite difference schemes* , Journal of Computational Physics, **157**, 588–617, 2000.

3. Tam, C.K.W. and Zaman, K.B.M.Q. *Subsonic jet noise from non-axisymmetric and tabbed nozzles* , AIAA Journal, **38**, 592–599, 2000.

4. Shen, H. and Tam, C.K.W. *Effects of jet temperature and nozzle-lip thickness on screech tones* , AIAA Journal, **38**, 762–767, 2000.

5. Tam, C.K.W., and Aganin, A. *Computation of transonic nozzle sound transmission and rotor problems by the dispersion-relation-preserving* scheme. Proceedings of the 3rd CAA Workshop on Benchmark Problems, pp 191-202, NASA CP-2000-209790, Aug 2000.

6. Shen, H. and Tam, C.K.W. *Three dimensional numerical simulation of the jet screech phenomenon*, AIAA Journal, vol. 40 (to appear Feb. 2002).

7. Tam, C.K.W. *Computational Aeroacoustics examples showing the failure of the acoustic analogy theory to identify the correct noise sources.* To appear in the June 2002 issue of the Journal of Computational Acoustics.